

## SECTION 232113.33 - GROUND-LOOP HEAT-PUMP PIPING

## PART 1 - GENERAL

## 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, Federal Acquisition Regulations and Division 01 Specification Sections, apply to this Section.

## 1.2 SUMMARY

- A. This Section includes piping for vertical, direct-buried, ground-loop, heat-pump systems that operate between 32 and 104 deg F

## 1.3 PERFORMANCE REQUIREMENTS

- A. Components and installation shall be capable of withstanding the following minimum working pressure, unless otherwise indicated:
  - 1. Ground-Loop, Heat-Pump Piping: 200 psig.

## 1.4 SUBMITTALS

- A. Product Data: For the following:
  - 1. Pipe and fittings.
  - 2. Joining method and equipment.
- B. Field quality-control test reports.

## 1.5 PERMITS

- A. Before commencement of any works, the Contractor shall be responsible for checking compliance with local and state regulations, and obtaining any permits relating to the geothermal system, both for installation and use.

## PART 2 - PRODUCTS

## 2.1 PIPES AND FITTINGS

- A. PE Pipe: ASTM D 2239, SDR Numbers 5.3, 7, 9, or 11.5; with PE compound number required to achieve required system working pressure.

1. Molded PE Fittings: ASTM D 2683 or ASTM D 3261, PE resin, socket- or butt-fusion type, made to match PE pipe dimensions and class.
- B. U-Bend Assembly: Factory fabricated with embossed depth stamp every 24 inches from U-bend.

## 2.2 BOREHOLE BACKFILL

- A. General: Thermally-enhanced bentonite grout shall be used to seal and backfill each vertical u-bend well bore of the closed-loop ground heat exchanger to insure proper thermal contact with the earth and to ensure the environmental integrity of each vertical bore column. The grouting material shall remain in a plastic state (moldable) throughout the life of the system and shall not generate heat during the hydration process. No other backfill material shall be accepted.
- B. Submittals: Manufacturer's published product submittal information sheets which shall include mixing instructions, minimum thermal conductivity performance, permeability, percent solids, grout weight, linear shrinkage potential and unit yield along with verification of the required listing(s). Grouting compound (bentonite-based and silica sand additive) shall be certified and listed by NSF (National Sanitation Foundation International) to ANSI/NSF Standard 60, *"Drinking Water Treatment Chemicals - Health Effects"*.
- C. Product: Grouting material shall be one of Black Hills Bentonite's Thermal Grout products as supplied by GeoPro, Inc. or pre-approved equivalent. The thermal enhancement compound (high-grade silica sand) shall also be specified and supplied by the developer and supplier of the bentonite base material.
- D. Thermal Conductivity: The thermal conductivity of the grouting compound must be 1.2 Btu/hr-ft-°F or greater as determined when tested in accordance to ASTM D-5334, *"Standard Test Method for Determination of Thermal Conductivity of Soils and Soft Rock by Thermal Needle Probe Procedure"* per International Ground Source Heat Pump Association (IGSHPA) Standard 2B.1.2.1. The reported thermal conductivity value shall be verified by an independent company which has a minimum of 5 years experience in measuring thermal conductivity using this method. A copy of the verification report shall be supplied upon request from the engineer.
- E. Permeability: The grout mixture shall also have a maximum permeability rate of less than 8.0 x 10<sup>-8</sup> cm/s as determined by using ASTM D-5084, "Measurement of Hydraulic Conductivity of Saturated Porous Materials using a Flexible Wall Permeameter, Method C - test with increasing tailwater level", per IGSHPA Standard 2B.1.2.2, with a 5 psi confinement pressure (to simulate an approximate sample depth of 5 foot). The reported permeability shall be verified by an independent, lab which has been certified by AMRL (American Association of State Highway & Transportation Officials, Materials Reference Laboratory) and validated by the US Army Corps of Engineers to perform ASTM D-5084 at the time of verification as found on the Internet at "<http://www.wes.army.mil/SL/MTC/ValidatedLabsList.htm>" per IGSHPA Standard 2B.1.2.3. A copy of the report shall be supplied upon request from the engineer. Credentials of the independent laboratory shall also be supplied upon request from the engineer.
- F. The thermally enhanced bentonite grout used shall have a minimum manufacturer's recommended mixture of 71 % solids. The thermal enhancement compound (high-grade silica compound) shall constitute a minimum of 63% by weight of the total aqueous slurry. The installed grouting material shall be fully set into a putty consistency within a minimum of 4

hours after being pressure pumped in the vertical bore annulus. Bentonite and thermal enhancement compound shall be pre-manufactured and pre-packaged prior to delivery to the job site. Bentonite and thermal enhancement compound shall be pre-manufactured and pre-packaged prior to delivery to the job site.

### PART 3 - EXECUTION

#### 3.1 EARTHWORK

- A. Excavating, trenching, warning tape, and backfilling are specified in Division 31 Section "Earth Moving."
- B. A preliminary test drill and formation thermal conductivity test has been performed on the site, the results of which are available for Contractor review. This bore hole will be re-used within the final geothermal scheme.
- C. Existing site conditions
  - 1. The existing parade ground, adjacent the N232 site, is the proposed location of the geothermal field. The contractor shall note the following:
  - 2. The parade ground has an existing irrigation system with underground piping: At the completion of the geothermal well installation, the contractor shall restore & repair this system to the satisfaction of the COTR.
  - 3. A number of existing site utility services pass through or adjacent the parade ground site. Approximate locations are indicated on drawing M140. It shall be the responsibility of the contractor to ensure these services are located, protected where necessary and kept live during the duration of the drilling works.
- D. Site works
  - 1. Before starting any work, install a 6' high temporary fence, to be in place throughout construction. Provide an erosion control silt fence. Coordinate construction gate access gate location with the COTR.
  - 2. Where geothermal pipework crosses the roadway, coordinate any lane closures with the COTR. The COTR shall be notified of any closures 3 weeks in advance.
  - 3. Upon completion of the works, the parade ground area shall be restored by sodding to a condition equal to that existing before the Contractor's work started. Finish grades shall be uniform with no ruts.
  - 4. All work shall be completed within 90 days after installation of the temporary fence.
- E. Drilling.
  - 1. The contractor shall allow for reuse of the test bore within the final scheme. Submit plans showing the bore-hole locations for review to the COTR a minimum of 3 weeks before the commencement of works.
  - 2. The Contractor shall submit all proposed drilling methods and techniques (e.g. wet rotary or hollow-stem auger) and methodology to the COTR a minimum of 3 weeks before the commencement of works.

3. Borehole diameter shall be minimized to reduce drilling costs and reduce mud flow. Target diameter 4.5 inches. Maximum acceptable diameter 6 inches. The Contractor shall inform the COTR of any adverse site conditions encountered during the drilling, complete with a mitigation plan to offset.
4. Review drilling parameters for indications of lost circulation and/or caving.
5. Review water quality test results—pH, calcium.
6. Review in-situ test loop results, record grout flow rate, volume injected, and pressure.
7. Make sure hydrostatic pressure was calculated for loop filled with water and for weight of grout used.
8. Review driller's logs for previously drilled holes in the area.
9. Check loop length numbers stenciled on pipe.
10. Check pipe specification numbers on pipe prior to installation and record.

### 3.2 VERTICAL PIPING INSTALLATION

- A. Install PE piping in boreholes according to ASTM D 2774 or ASTM F 645.
  1. Clean PE pipe and fittings and make heat-fusion joints according to ASTM D 2657. Minimize number of joints.
- B. Purge, flush, and pressure test piping before backfilling boreholes.
- C. After installation of loop pipe in borehole, fill piping loop with water or antifreeze solution, and pump bentonite backfill into borehole to discharge at base of borehole using a tremie pipe.
- D. Fill borehole with bentonite backfill to a point at least 60 inches below grade and backfill remainder with surface seal material.
- E. Extend piping and connect to water-source, ground-loop, heat-pump piping systems at outside face of building wall in locations and pipe sizes indicated.
  1. Terminate water-service piping at building wall until building water-source, ground-loop, heat-pump piping systems are installed. Terminate piping with caps. Make connections to building water-source, ground-loop, heat-pump piping systems when those systems are installed.
- F. Wall sleeves are specified in Division 23 Section "Sleeves and Sleeve Seals for HVAC Piping."
- G. Mechanical sleeve seals are specified in Division 23 Section "Sleeves and Sleeve Seals for HVAC Piping."

### 3.3 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.

### 3.4 GROUTING

- A. Installation: Thermally enhanced bentonite grouting material shall be mixed according to manufacturer's written instructions. Grout material shall be pressure pumped through a one (1) inch, one and one-quarter (1-1/4) inch or a one and one-half (1-1/2) inch inside diameter tremie pipe and placed in the bore column from the bottom to the top. Grouting process shall conform to the manufacturer's instructions and *"Grouting for Vertical Geothermal Heat Pump Systems -- Engineering Design and Field Procedures Manual"*, as published by the IGSHPA, Oklahoma State University (OSU), 2000. Completed grouted surface shall be placed at ground level to ensure complete fill of the bore column.

### 3.5 FIELD QUALITY CONTROL

- A. Piping Tests: Fill piping 24 hours before testing and apply test pressure to stabilize piping. Use potable water only.
- B. Hydrostatic Tests: Test at not less than 1-1/2 times the pipe working-pressure rating allowing for static pressure of borehole depth.
  - 1. Increase pressure in 50-psig increments and inspect each joint between increments. Hold at test pressure for 30 minutes. Slowly increase to next test pressure increment and hold for 30 minutes. After testing at maximum test pressure, reduce pressure to 30 psig Hold for 90 minutes, and measure pressure at 30-minute intervals. Repair leaks and retest until no leaks exist.
- C. Prepare reports of testing activity. Reports to include for a minimum of the following
  - 1. Driller's logs to depth in local area.
  - 2. Site layout of loop header installation locations.
  - 3. Size and lengths of loops and headers with loop pipe length numbers on pipes.
  - 4. Pipe specifications and record of those shown on pipe.
  - 5. Size and length of grout injection pipe.
  - 6. Estimate of extent of caving in hole, barrels of cuttings.
  - 7. Record grout specification and supplier mixing recommendations.
  - 8. Record mixing procedure, ratios, and volumes.
  - 9. Record water test results for pH and calcium content.
  - 10. Record grout test results for viscosity and weight.
  - 11. Record problems and solutions.
  - 12. In-situ loop thermal test report.
- D. Grouting Inspection: Since some settling may occur after initial placement of the grout material, the Contractor shall monitor each borehole and continue adding grout as required for a period of no less than thirty (30) minutes and no longer than two (2) hours. Since there usually is a direct correlation between thermal conductivity and permeability, only thermal conductivity shall be field inspected. The grouting manufacturer shall provide testing of site mixed grouting material in accordance to ASTM D-5334 to verify thermal conductivity. Manufacturer shall provide a minimum of three, sample analysis for this project. At a minimum, sampling shall be taken once at the beginning of the project, once at approximately one-third of completion, and finally at approximately two-thirds of completion. In the event that the analysis indicates a thermal conductivity value below the minimum specified value, corrective action shall be taken

to increase thermal conductivity value back to minimum specified requirement. A written report will be submitted defining corrective action taken.

END OF SECTION 232113.33